DOE Hydrogen Program

Pre-Solicitation Meeting

San Antonio, TX - October 15, 2007

Hydrogen Storage Engineering Center of Excellence

Office of Energy Efficiency & Renewable Energy
Hydrogen, Fuel Cells and Infrastructure Technologies
Hydrogen Storage Team

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DOE Hydrogen Program

Today's Agenda:

- **Distribution of Question Cards**
- **3:30 DOE Presentation**
- **4:00 Collection of Questions (onsite and web cast)**
- **4:30 Q & A Session**

Presentation materials and Q&A will also be posted at www.hydrogen.energy.gov

Note:

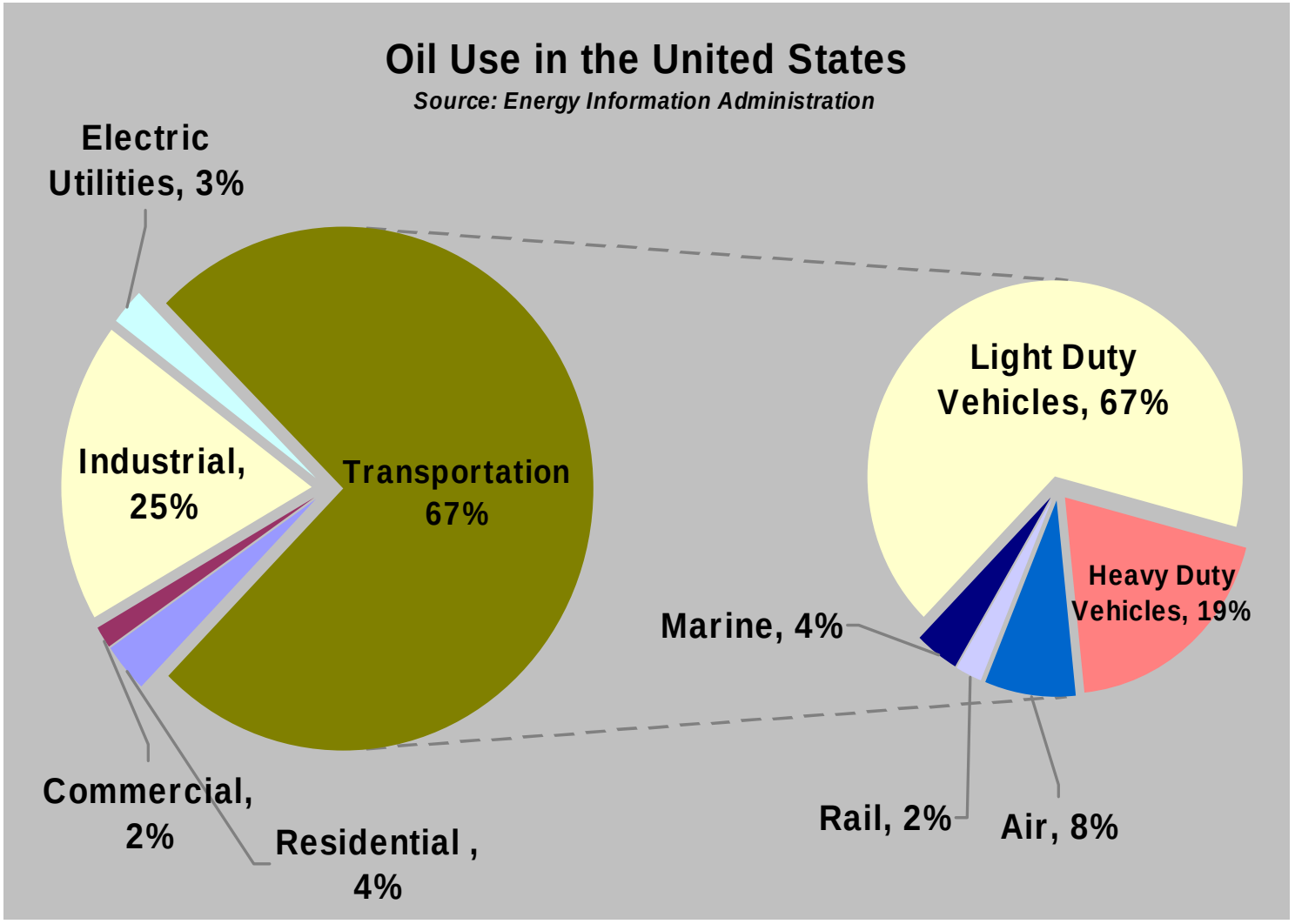
- **This Financial Opportunity Announcement (FOA) is subject to appropriations**
- **The material presented today is DRAFT and subject to change in the final FOA**

Outline

- **Background**
  - History of DOE Hydrogen Storage Investment
  - Hydrogen Storage Goals & Status of H_2 Storage Technology

- **New Hydrogen Storage Engineering Center of Excellence**
  - Objectives and Expected Outcomes
  - Planned Topics
  - CoE Structure
  - Merit Review Criteria & Scoring
  - Coordination Website
  - Reporting & Meetings-Post Award

The transportation sector accounts for 2/3 of oil use in the United States, mostly in light-duty vehicles.



President's Hydrogen Fuel & Advanced Energy Initiatives accelerate R&D in hydrogen and fuel cell technologies

Program History

- **2003 Grand Challenge Solicitation (EERE):**
  - 3 Material-focused CoEs: Chemical Hydrogen Storage, Metal Hydride & Sorbents/Carbon
  - Independent projects addressing new materials & concepts
- **2005 & 2007 Basic Research Needs for the Hydrogen Fuel Initiative Solicitations (BES)**
  - 2005: 17 new hydrogen storage basic research projects
  - 2007: 7 basic research projects
  - Cross-cutting research in core portfolio also contributes
- **2006 EERE Annual "New Ideas" Solicitation Initiated**
  - 4 materials projects as new partners for existing CoEs
  - 2 new independent safety materials projects

Engineering is a research gap within the existing portfolio to be addressed by new CoE.

Technology R&D – H_2 Storage

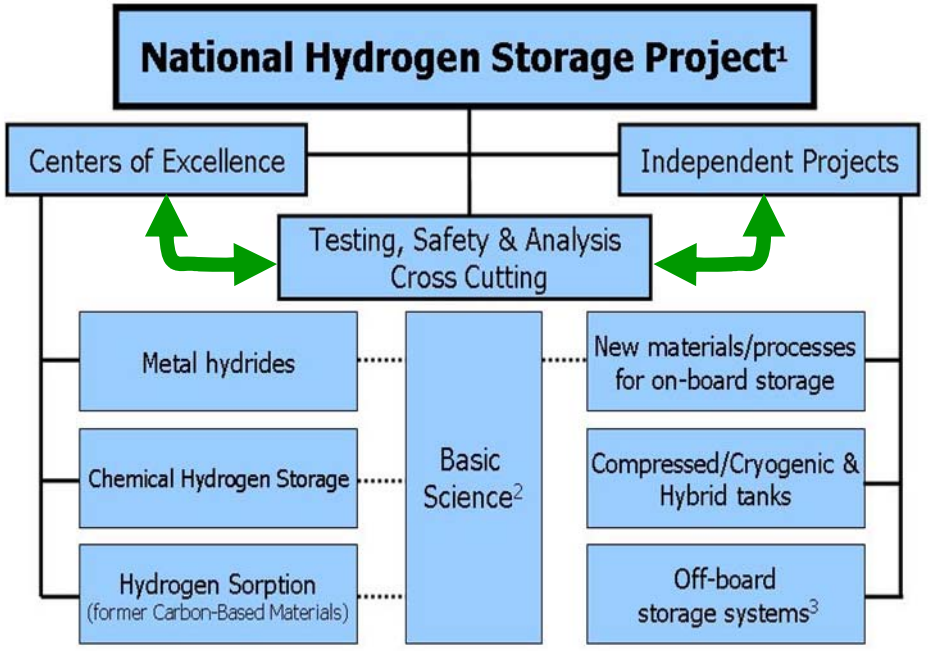
KEY OBJECTIVE: *On-board H_2 storage to enable* ***> 300 mile driving range*** *while meeting all requirements for safety, cost, and performance (weight, volume, kinetics, etc.)*

NEAR TERM: ***Allows for early market use of H_2 vehicles, but won't provide full range without reducing interior space***

- Pressurized tanks: *currently in use in most H_2 vehicles*
- Cryo-compressed storage: *combines low-temperature H_2 storage with pressurization*

LONGER TERM: ***Needed to enable >300-mile range***

- *Diverse portfolio with materials focus, for low-pressure storage*
- *Focus materials research on temperature, pressure, kinetics (as well as capacity)*



1. Coordinated by DOE Energy Efficiency and Renewable Energy, Office of Hydrogen, Fuel Cells and Infrastructure Technologies
2. Basic science for hydrogen storage conducted through DOE Office of Science, Basic Energy Sciences
3. Coordinated with Delivery Program element

DOE Storage System Targets

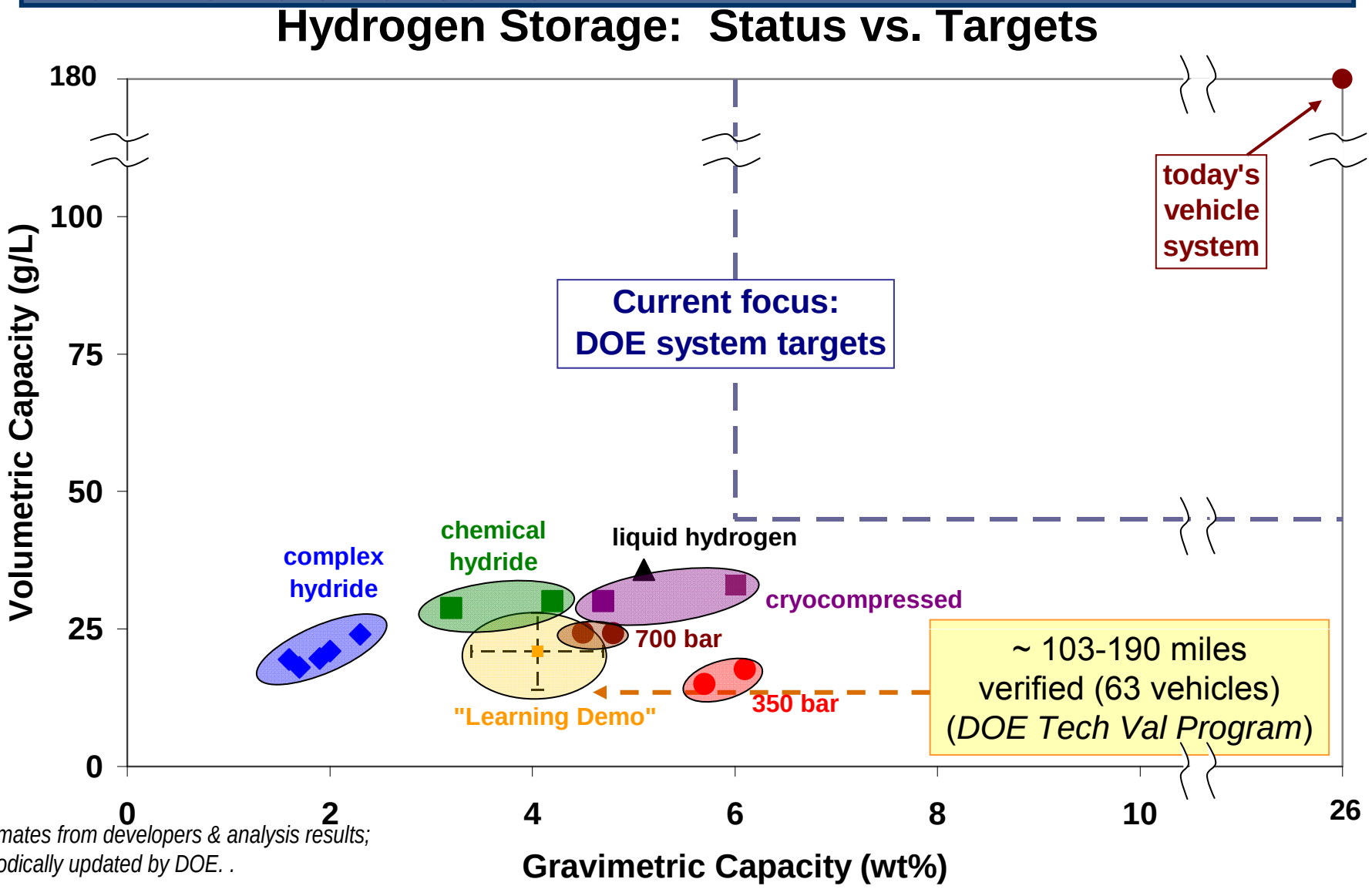
Technical Targets: On-Board Hydrogen Storage Systems

Storage Parameter	Units	2007	2010	2015
System Gravimetric Capacity: Usable, specific-energy from H_2	kWh/kg (kg H_2/kg system)	**1.5** **(0.045)**	**2** **(0.06)**	**3** **(0.09)**
System Volumetric Capacity: Usable energy density from H_2	kWh/L (kg H_2/L system)	**1.2** **0.036**	**1.5** **0.045**	**2.7** **0.081**
Storage system cost [b] (& fuel cost)[c]	$/kWh net ($/kg H_2) $/gge at pump	6 (200) ---	4 (133) 2-3	2 (67) 2-3
Durability/Operability •Operating ambient temperature [d] •Min/max delivery temperature •Cycle life (1/4 tank to full) [e] •Cycle life variation [f] •Min delivery pressure from tank; FC= fuel cell, I=ICE •Max delivery pressure [g]	 ºC ºC Cycles % of mean (min) at % confidence Atm (abs) Atm (abs)	 -20/50 (sun) -30/85 500 N/A 8FC / 10ICE 100	 -30/50 (sun) -40/85 1000 90/90 4FC / 35ICE 100	 -40/67 (sun) -40/85 1500 90/90 4FC / 35ICE 100
Charging/discharging Rates •System fill time (for 5 kg) •Minimum full flow rate •Start time to full flow (20 ºC) [h] •Start time to full flow (- 20 ºC) [h] •Transient response 10%-90% and 90% -0%[i]	 min (g/s)/kW s s s	 10 0.02 15 30 1.75	 3 0.02 5 15 0.75	 2.5 0.02 5 15 0.75
Fuel Purity (H_2 from storage)[j]	% H_2	99.99 (dry basis) See Appendix C		
Environmental Health & Safety •Permeation & leakage [k] •Toxicity •Safety •Loss of useable H_2 [l]	Scc/h - - (g/h)/kg H_2 stored	Meets or exceeds applicable standards		
		1	**0.1**	**0.05**

There are many more DOE targets, not just wt%!

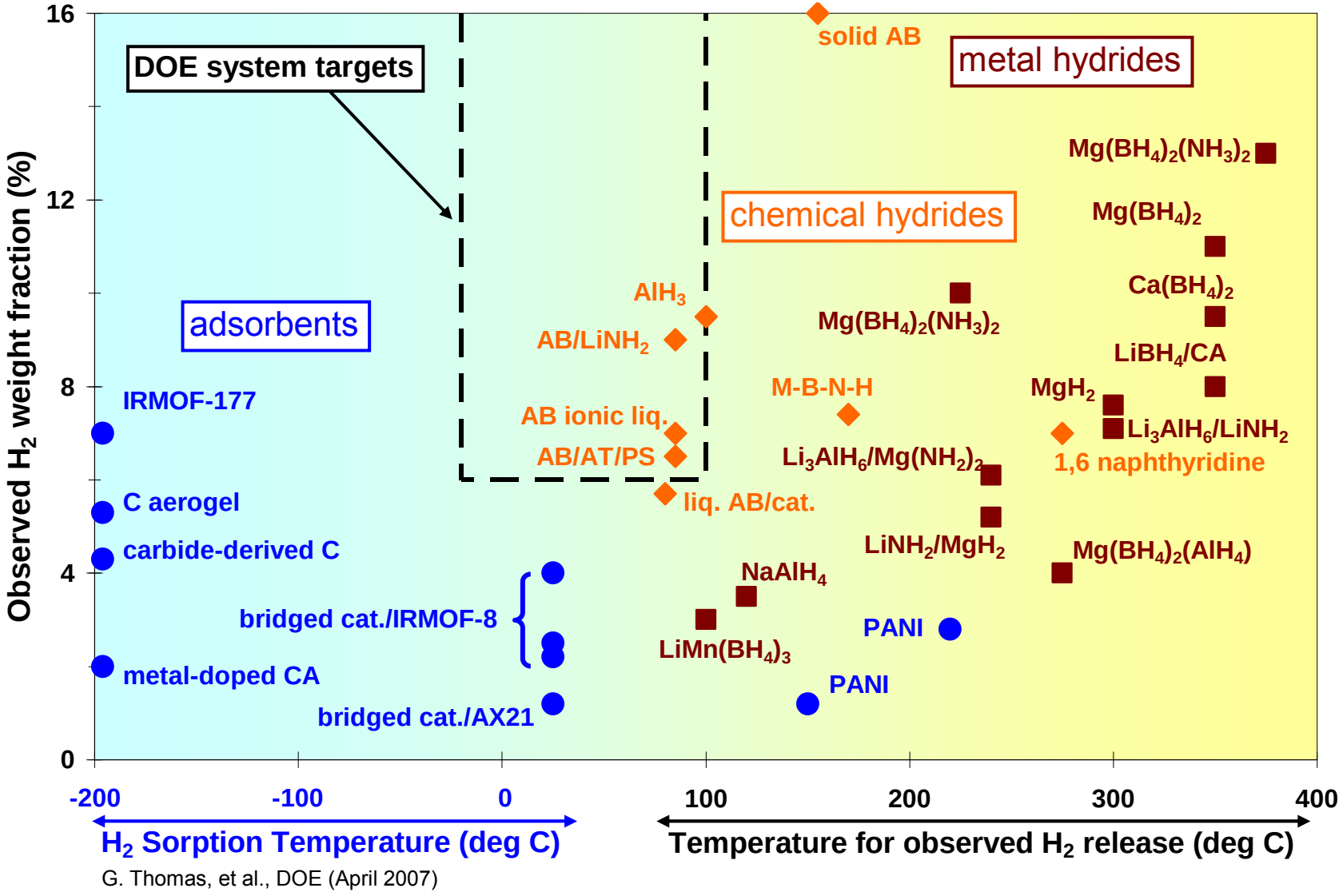
R&D Systems Status

No technology meets targets—Results include data from vehicle validation



Estimates from developers & analysis results; periodically updated by DOE. .

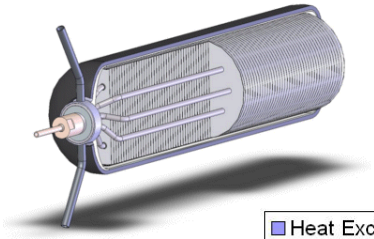
Progress: Material Capacity vs. Temperature

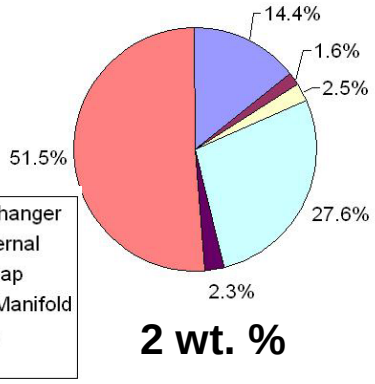


G. Thomas, et al., DOE (April 2007)

Preliminary prototypes built and tested

2nd Gen Complex Hydride Prototype Built (Ti-$NaAlH_4$)





2 wt. %

Estimated 2.0 wt% & 21 g/L

(Projected 2.3 wt.% and 24 g/L)

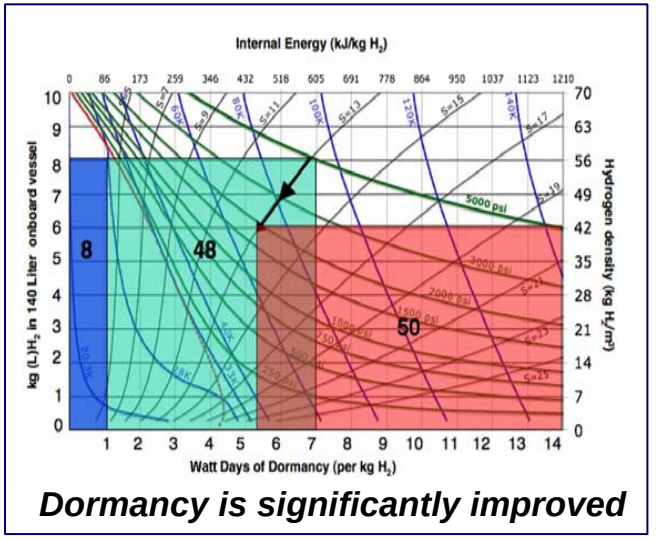
Key Issues:

- *Kinetics; thermal integration*
- *Material packing*
- *Reversible capacity at low temp*
- *Depth of discharge*

Mosher et al., UTRC

Cryo-Compressed Tank Concept Demonstrated

- *High P for urban driving & LH_2 for maximum range*
- *LH_2 boil-off is reduced*
- *4.7% H_2 wt. and 30 g/L (ANL estimate)*



Dormancy is significantly improved

LLNL's Cryocompressed tank in Quantum-LLNL modified hydrogen fueled vehicle.

Aceves, Berry, et al. LLNL

Engineering CoE Objectives

Emphasis on Fuel Cell Vehicles; also address ICEs

- Utilize understanding of system requirements for light-duty vehicles to design innovative components & systems
- Develop innovative on-board system concepts for material-based technologies
- Develop engineering, design, & system models which address on-board subsystems & the fuel cycle
- Design, fabricate & test subscale (eg, ≤1 kg material) prototype fixtures, components and/or systems

Engineering of off-board regeneration processes of spent chemical materials not within scope.

Key Issue: Interactions with existing materials CoEs

CHCoE

MHCoE

HSCoE

STOP?

Current materials CoEs end in FY2010
May be re-competed (TBD)
No 1-kg H or sub-scale prototypes will be built

EngCoE

1 2 3

EngCoE may be 4 or 5 yrs in length in up to 3 phases
Up to 3 sub-scale prototypes planned in phase 3 (metal hydride, sorbent and/or chemical hydride)

New partners may be added to the CoE in the future through the annual Storage FOA

Engineering CoE Topics

Topics require multidisciplinary approach

- **Systems engineering for vehicular applications**
  - Interactions of key subsystems; interface to power plant (fuel cell or ICE); refueling; storage-delivery interface
- **Energy management**
  - Impact of required heat/mass transport
  - Operating requirements for materials
  - Transients; refueling and dispensing issues; shutdown & startup
- **Novel component & reactor designs**
  - Conformable light-weight and compact components
  - Design for manufacturability and cost
  - Integration & packaging of major sub-systems
- **Concept evaluation & sub-scale prototype testing**
  - Develop up to 3 sub-scale prototypes for each method (e.g. chemical hydrogen storage, metal hydrides & sorbents)

Engineering CoE will consist of 3 phases.

Phase 1: Understand System Requirements & Define Novel Concepts

- System configurations
- Energy management
- Materials operating requirements
- Engineering modeling & validation
- System performance analysis

Phase 2: Novel Components & System Concept Designs

- Continue & expand Phase 1 work content
- Develop & evaluate concept designs
- Update system analysis projections & models

Phase 3: Sub-scale Prototype Construction, Testing & Evaluation

- Up to 3 (three) sub-scale (e.g., 1 kg material) prototypes based materials:
  - Reversible above room temperature
  - Reversible at/below room temperature
  - Off-board regenerable materials

Engineering CoE Structure

No prescribed CoE Lead Member/Structure/Mix

- No predetermined team structure or mix
- Team formed by applicants to address technical scope of work and review criteria
- Existing members of materials CoEs can apply: No limitations

- Team lead: Domestic entity (university, company, nonprofit or laboratory)
- Partner: Domestic entity (university, company, nonprofit or laboratory); Non-US entity could be subcontractor

- It is anticipated that 1 team will be selected

Funding: 1 TEAM: $25 to 30M over 4 to 5 years plus 20% non-fed cost share

Engineering CoE Structure

The planned FOA is intended to fund one team to complement the existing National H2 Storage Project

- The proposed CoE team is required to submit two types of applications, Category 1 and Category 2
  - Category 1 -The team lead coordination and management role
  - Category 2 - The technical partners with detailed technical work
- NOTE that if a team lead proposes technical work, the lead must submit a separate application under Category 2
- A technical partner must submit two separate Category 2 applications if applying under two proposed centers
- Team's Category 1 score and Category 2 scores will determine the overall Engineering CoE team score
- Upon selection, DOE will negotiate a separate award with each partner

The team lead and each technical team partner must submit their own stand alone application under the FOA.

Team lead and individual applications required.

Category 1 & Category 2 Application Content

Category 1: Team Lead Application (40% of CoE score)

- Overall CoE scope & management plan
  - CoE strategy
  - CoE technical approach & work plan
  - CoE management & coordination
  - Liaison plan with storage materials projects
  - Partner roles & responsibilities
  - IP management plan
  - Communications plan (internal & external)
- Center Director qualifications
- Lead organization qualifications & experience
- How safety is addressed for CoE

Category 2: Technical Partner Applications (60% of CoE score)

Category 2 Contains the "DETAILS"

- Technical scope of work & work plan for the partner
- Detailed work breakdown structure
- Partner qualifications & facilities
- Individual safety plans

Merit Review Criteria for Team Lead Application (Cat 1)

Two criteria will be used by reviewers for Category 1.

Overall Scope and Management Plan (~60%)

- Scope of CoE in meeting DOE objectives
- Mix of skills of team to meet objectives
- Management plan of the CoE
  - ➢Clarity of goals & objectives
  - ➢Roles & responsibilities of team members
  - ➢Overall task management plan
  - ➢IP management plan
  - ➢Communications plan (internal & external)
  - ➢Plan for safety plan

Team Lead Qualifications (~40%)

- Center director qualifications
- Lead team experience & qualifications
- Lead Organization qualifications
- Organization experience

Merit Review Criteria for Partner Cat 2 Application

Three criteria will be used by reviewers for Category 2.

Technical Concept & Approach (45%)

- Relevance of technical concept
- Technical viability
- Innovation and advantages of approach
- Technical risk mitigation
- Potential to advance technology

Work Plan of Partner (~40%)

- Clarity of goals & objectives
- Task management plan
- Work breakdown structure
- Communication plan
- Safety plan

Partner Qualifications (~15%)

- Personnel qualifications
- Organization qualifications, experience & facilities

An institution proposing as lead (Cat 1) must submit an individual CAT 2 application for technical work.

Rolled-Up Team Scoring System

Team Lead & Individual Partner Scores will be Rolled into one "Overall Team Score"

- Total Possible Team Score is 1000
- 40% of the 1000 is based on the Category 1 Team Lead Application
    - The Criteria weighting for Category 1:
        1) 60% for Criterion 1 (Scope & Management Plan)
        2) 40% for Criterion 2 (Lead Qualifications)
- 60% of the 1000 is based on the sum of the Category 2 Partner Applications
    - The Criteria weighting for Category 2:
        1) 45% for Criterion 3 (Concept & Approach)
        2) 40% for Criterion 4 (Work Plan)
        3) 15% for Criterion 5 (Partner Qualifications)
- To roll up the scores, a "Percent Contribution" for each Category 2 partner must be identified in the Category 1 Application
    - The reasonableness of the "Percent Contribution" is included in the Merit Review Criterion 1
- The Percent Contribution of the Team Lead is Fixed at 40%
- All of the other Category 2 Partner's percent contribution must sum to 60% (all partners must be included in the percent contribution)

Website planned for expression of interest

Partnering website planned to facilitate formation of teams

- **One-pager on partner's interests & capabilities**
- **On-line "resume-builder" to form teams**
- **Facilitate inclusion of new institutions into program**
- **No prescribed make-up of team structure (e.g. lead, number of partners, type of partners)**

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Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Hydrogen, Fuel Cells & Infrastructure Technologies Program

Register for the Partner Directory

Registering for the Hydrogen Storage Engineering Center of Excellence Partner Directory allows potential research partners to view your organization information. To register, please complete the following form. Then click the Submit button.

*Fields marked with an asterisk are required.

Organization Name and Address

*Organization Name:

Address 1: Address 2:

*City: *State: Choose...

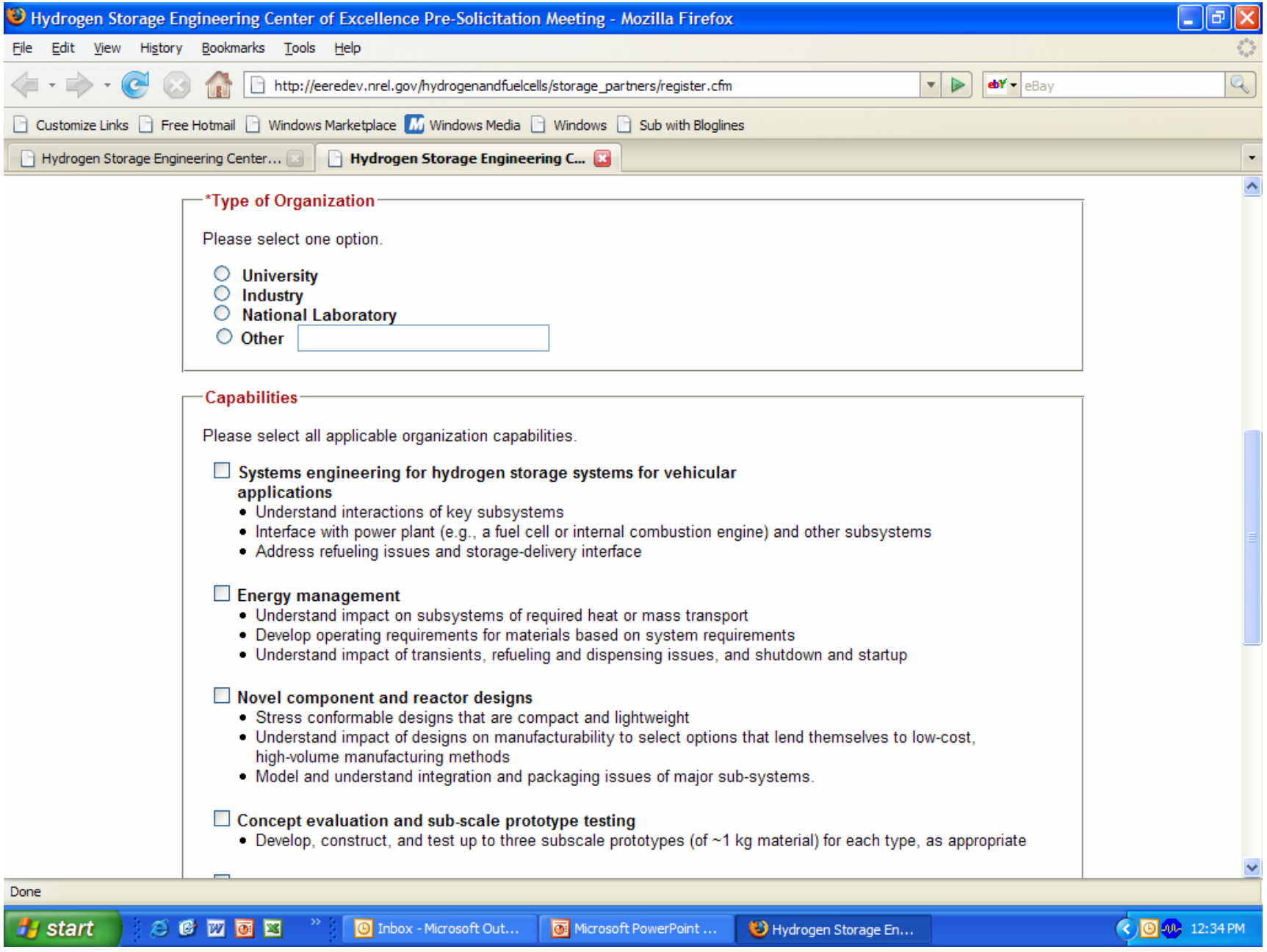
*Zip: 00000[-0000]

Contact

*First Name: *Last Name:

Phone: (000) 000-0000 Fax: (000) 000-0000

*E-mail: Web Site: (include http://)


Hydrogen Storage Engineering Center of Excellence Pre-Solicitation Meeting - Mozilla Firefox
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http://eeredev.nrel.gov/hydrogenandfuelcells/storage_partners/register.cfm
Customize Links Free Hotmail Windows Marketplace Windows Media Windows Sub with Bloglines
Hydrogen Storage Engineering Center...
Hydrogen Storage Engineering C...
*Type of Organization
Please select one option.
University
Industry
National Laboratory
Other
Capabilities
Please select all applicable organization capabilities.
Systems engineering for hydrogen storage systems for vehicular applications
Understand interactions of key subsystems
Interface with power plant (e.g., a fuel cell or internal combustion engine) and other subsystems
Address refueling issues and storage-delivery interface
Energy management
Understand impact on subsystems of required heat or mass transport
Develop operating requirements for materials based on system requirements
Understand impact of transients, refueling and dispensing issues, and shutdown and startup
Novel component and reactor designs
Stress conformable designs that are compact and lightweight
Understand impact of designs on manufacturability to select options that lend themselves to low-cost, high-volume manufacturing methods
Model and understand integration and packaging issues of major sub-systems.
Concept evaluation and sub-scale prototype testing
Develop, construct, and test up to three subscale prototypes (of ~1 kg material) for each type, as appropriate
Done
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Hydrogen Storage Engineering Center of Excellence Pre-Solicitation Meeting - Mozilla Firefox

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http://eeredev.nrel.gov/hydrogenandfuelcells/storage_partners/

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Hydrogen, Fuel Cells & Infrastructure Technologies Program

Hydrogen Storage Engineering Center of Excellence Partner Directory

The Hydrogen Storage Center of Excellence Partner Directory matches potential research partners for Hydrogen Storage Engineering Center of Excellence solicitation applications. The directory provides contact and capabilities information for organizations interested in creating research partnership teams.

The Department of Energy Office of Energy Efficiency and Renewable Energy is soliciting applications from multidisciplinary teams to advance on-board hydrogen storage systems, a key enabling technology for hydrogen-fueled vehicles. The solicitation seeks to fund a virtual Center of Excellence in Hydrogen Storage Engineering to support the research and development of viable hydrogen storage systems for on-board vehicular applications. The solicitation is intended to fund one team to complement the existing National Hydrogen Storage Project activities.

For more information about application requirements and submission, see the full solicitation.

To notify potential partners of your capabilities, register for the partner directory.

To find proposal partners, search the partner directory.

Done

start Inbox - Microsoft Out... Microsoft PowerPoint ... Hydrogen Storage En... 12:32 PM

Tentative Schedule

The Following Schedule is only an estimate and is subject to appropriations

- Pre-Solicitation Meeting ……..……10/15/07
- All Q's & A's from Pre-Solicitation Meeting Posted to Website (http://hydrogen.energy.gov/).....10/31/07
- Funding Opportunity Announcement Released…....Dec 07
- Applications Due……..…Mar 08
- Selection Announced……..……Jun 08
- Initial Awards Made……..……Aug 08

Meetings and Reports – Post Award

Meetings:

- Kick off meeting
- FreedomCAR & Fuel Partnership Tech Team meeting, nominally once per year in Detroit
- Hydrogen and Fuel Cells Annual Program Review, DC
- On-site DOE visit/review/conf calls
- Face-to-face CoE meetings and teleconferences (at least 2/yr)

Reports:

- Annual Progress Report
- Quarterly reports- technical plus financial

  Attach preprints/reprints/slides as needed
- National Labs must submit draft AOPs to HQ in June of every year
- Safety Plan
- Final Technical Report

For More Information

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Additional Information

Applied R&D Hydrogen Storage "Grand Challenge" Partners:
Diverse Portfolio with University, Industry and National Lab Participation

Centers of Excellence

Metal Hydride

National Laboratory:
- Sandia-Livermore

Industrial Partners:
- General Electric
- HRL Laboratories
- Intematix Corp.
- UTRC

Universities:
- CalTech
- Stanford
- Pitt/CMU
- Hawaii/UNB
- Illinois
- Nevada-Reno
- Utah

Federal Lab partners:
- Brookhaven
- JPL, NIST
- Oak Ridge
- Savannah River

Hydrogen Sorption

National Laboratory:
- NREL

Industrial Partners:
- Air Products & Chemicals

Universities:
- CalTech
- Duke
- Penn State
- Rice
- Michigan
- North Carolina
- Miami Univ. of Ohio

Federal Lab partners:
- Lawrence Livermore
- NIST
- Oak Ridge
- Argonne

Chemical Hydrogen Storage

National Laboratories:
- Los Alamos
- Pacific Northwest

Industrial Partners:
- Intematix Corp.
- Millennium Cell
- Rohm & Haas
- Borax

Universities:
- Northern Arizona
- Penn State
- Alabama
- California-Davis
- Univ. of Missouri
- Pennsylvania
- Washington

Independent Projects

Advanced Metal Hydrides
- UTRC/Savannah River NL
- UOP
- UConn

Sorbent/Carbon-based Materials
- UCLA
- State University of NY, ESF
- Gas Technology Institute
- UPenn/Drexel Univ.

Chemical Hydrogen Storage
- Air Products & Chemicals
- RTI
- Millennium Cell
- Safe Hydrogen LLC

Other New Materials & Concepts
- Alfred University
- Michigan Technological University
- UC-Berkeley/LBL
- UC-Santa Barbara

Tanks, Safety, Analysis & Testing
- Lawrence Livermore Nat'l Lab
- Quantum
- Argonne Nat'l Lab, TIAX LLC
- SwRI, UTRC, Sandia NL
- Savannah River NL

Coordination with: Basic Science (Office of Science, BES)

MIT, U.WA, U. Penn., CO School of Mines, Georgia Tech, Louisiana Tech U., U. Georgia, U. Missouri-Rolla, Tulane U., Southern Illinois U., Rutgers, Stony Brook, UC Davis, UC Santa Barbara, U. Missouri-Columbia, U. South Florida; Labs: Ames, BNL, LBNL, ORNL, PNNL, SRNL

Rolled-Up Team Scoring System

Example Scoring Table

Team ABC % Contribution	Weighted %	Lead 40%	Partner 1 30%	Partner 2 20%	Partner 3 10%	Grand Total
Category 1 (Team Lead Application)						
Criterion 1 (Overall Scope & Mgmt Plan)	60%	10				
Criterion 2 (Team Lead Qualifications)	40%	9				
Category 1 Sub-Total	100%	384				384
Category 2 (Individual Technical Partner Applications)						
Criterion 4 (Technical Concept)	45%		8	5	2	
Criterion 5 (Work Plan)	40%		7	4	1	
Criterion 6 (Qualifications & Facilities)	15%		6	3	0	
Category 2 Sub-Total	100%		219	86	13	318
Overall Team Score						**702**

- % in Red will be defined in the FOA (locked)
- % in Green are the Percent Contributions for each Category 2 Partner
- Scores in Blue Represent Sample Merit Review Scores
- Example of Partner 1 Contribution Calculation:

$$219 = \{ [(8 \times 45\%) + (7 \times 40\%) + (6 \times 15\%)] \times 30\% \} \times 100$$

The Hydrogen Program has five focus areas addressing technical and economic barriers.

- **Technology Performance and Cost**
  - R&D to achieve cost and performance targets
    - Hydrogen Cost (target: $2.00 - 3.00 per gallon gasoline equiv.)
    - Hydrogen Storage (target: >300-mile range)
    - Fuel Cell Cost and Durability (targets: $30 per kW, 5000 hours)
  - Technology Validation through learning demonstrations
- **High Volume Manufacturing (FY 2008)**
- **Hydrogen Delivery Infrastructure**
  - Compression, liquefaction, off-board storage
  - Pipeline materials
- **Safety, Codes and Standards**
- **Education**